WARRAGUL WATER TREATMENT PLANT – COMMISSIONING AND OPTIMISATION

Paper Presented by :

Len Ablett

Author:

Len Ablett,
Warragul Water Treatment Plant Operator

Gippsland Water

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ABSTRACT

Gippsland Water has undertaken a review of water treatment plants and is modifying them to improve their performance in meeting World Health Organization quality parameters. A number of existing plants are very old and employ outdated technology, so where necessary, design and construction of new water treatment plants is also being considered and implemented.

Gippsland Water has opted to build a number of small package plants for communities where treated water production is less then three megalitres per day. Water treatment plants supplying water to larger areas including Moe, Warragul, Traralgon, and Morwell also required major extensions and refurbishment. In particular, the Warragul site posed a real problem in that it consisted of a 6m by 6m tin shed containing dosing pumps, chemical storage and instrumentation, a clarifier tank that was at least fifty years old and no filtration.

Clearly, modifications to the existing plant would not have been appropriate, so the Authority decided to construct a new plant. A Design and Construct tendering process was undertaken and a new Dissolved Air Flotation water treatment plant (DAF) was constructed. This is the first plant of this type in Gippsland Water's region.

After commissioning, the plant performance was still well below Gippsland Water's expectations and a number of process modifications were undertaken. This paper outlines some of these problem and the remedial actions undertaken.

1.0 INTRODUCTION

Warragul is located approximately 110 kilometers east of Melbourne. The Warragul Water Treatment Plant is situated 5 km's north of Warragul on the main Neerim South road and supplies water to Drouin, Buln Buln, Rokeby, Nilma, Darnun and Warragul. These towns have a combined population of approximately 20,000 people.

The raw water is supplied from Pederson Weir, located 8 km's up stream from the Tarago Reservoir. The raw water is supplied by gravity to the water treatment plant via a 450 mild steel concrete lined main, 32 km's in length and an 80m static head pressure. Hydraulic and reservoir supply limitations mean that the gravity main can supply only 12 ML per day.

The incoming raw water turbidity varies from 5 to 400 NTU, the Colour from 10 to 200 TCU. The raw water quality changes frequently, particularly during heavy rains and storms, and the old treatment plant had a lot of difficulty removing colour. It was able to handle low turbidity raw water, but did not automatically adjust the chemical dosing during varying or high raw water turbidity events.

The old plant had problems coping with the variable raw water quality with typical final treated water quality results ranging from around 0.7 to 1.2 NTU and colour ranged from 5 to 10 TCU for good quality raw water. Results were often much worse depending on the weather and raw water quality.

2.0 PLANT DESIGN

The design of the new treatment plant has a total capacity of 19 ML/day with two filter cells, each capable of 9.5 ML/day. The raw water enters the inlet mixing chamber where pin floc is formed. It then flows over two separate weirs into the flocculating chambers. There are then two flocculating tanks on each cell which mix on a two to one ratio. The first tank stirs at twice the speed of the second and the majority of agglomeration takes place in the second tank, where mixing speed and velocity is slower.

The water then progresses to the DAF chamber where the recycle water, incorporating the dissolved air, is added. The tiny air bubbles that are entrained in the water, float particles to the top before entering the main filter cell. Each filter cell has the filter media at the bottom so the treated water passes out the bottom of the cell. The filtered water is then pH corrected and flows via gravity to the reservoir. Each filter cell is approximately 7 m long by 5 m wide and 2.1 m deep.

The filter media is 1.8 m deep and comprises of the following layers:

- 100 mm of 6 to 12 mm gravel,
- 100 mm of 6 to 3 mm gravel,
- 100 mm of 3 to 1 mm gravel,
- 300 mm of 0.8 to 0.9 mm sand
- 1200 mm of 1 to 1.1 mm filter coal (other wise known as anthrocite).

The general DAF design had worked well in other areas of the State, particularly where manual control was utilised and where raw water was of a consistent quality. In order to achieve the project goals including reliable operation, high quality treated water and a minimal operator attendance requirement, several basic changes to the DAF plant were necessary due to varying raw water conditions. The Warragul raw water was particularly difficult to treat given that turbidity could vary from 10 NTU to 100 NTU in the space of two hours. Several faults with the plant were identified and works as outlined below were undertaken to improve the plant performance.

3.0 PROBLEMS IDENTIFIED AND IMPROVEMENTS UNDERTAKEN

3.1 Raw Water

The raw water turbidity meter was located in the laboratory, approximately 50 m away from the sample point at the inlet chamber. The sample line was a large diameter dead end pipe. The turbidity meter installed is a Hach 1620 which requires a flow of only 500 ml/min. Due to the distance from sample collection to meter and the low flow rate, the suspended particles in the raw water settled in the sample line prior to reaching the turbidity meter. This meant that the sample was not representative of the incoming raw turbidity. To overcome this problem, the turbidity meter was relocated close to the inlet chamber and a sample pump fitted to ensure full flow to the turbidity meter at all times. This corrected the problem and the plant raw water readings changed in line with the incoming raw water.

3.2 Chemical Dosing

The original treatment plant design provided for the alum dosing point to be located 50 m upstream from the inlet chamber and the pre lime dosing point (for pH correction to allow coagulation) in the inlet chamber. It was determined that the pin floc was breaking up before it reached the inlet chamber and the pre lime dosing did not have adequate time to correct the pH, to allow the reformation of pin floc in the flocculation tanks.

The pre lime dosing point was moved 50 m upstream from the inlet chamber (where the alum was originally dosed), to provide good mixing and the alum dosing point was relocated to 10 m before the inlet chamber. These changes worked well and provided good chemical mixing and conditions for coagulation. This enabled the treatment plant to operate well during consistent raw water quality, however still requiring to manual adjustment of chemical dosing as raw water quality changed.

3.3 Automated Alum Dose Adjustment

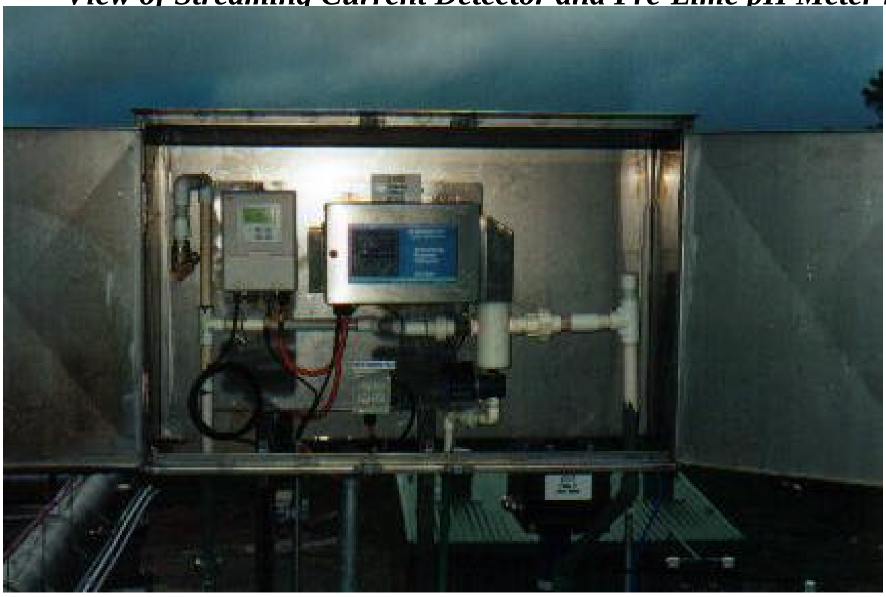
After much consideration, a dosing table was developed (alum dosage versus raw water turbidity, NTU) and tested. Although this table worked quiet well, it was proven not completely accurate, meaning that many jar tests were still required to determine the chemical dose rate.

The design of the DAFF plant included provision of a Streaming Current Detector (SCD) to be tested for suitability for controlling alum dosing in a treatment plant of this type. These units had not been used previously in Gippsland Water's plants for alum control. Once this unit was installed and operating, its performance was monitored.

After about three months of monitoring, testing and adjustment, involving several high raw water turbidity events, the (SCD) was able to ramp the alum dose rate up and down depending on the incoming raw water turbidity. The (SCD) also allowed for the colour variation and adjusts the alum and 1190 polymer doses to the correct levels. The (SCD) unit is susceptible to sudden pH variations however, with the pre lime dose point being 50 m upstream from the inlet chamber, it allowed the lime to be well mixed so that no lime particles could cause a false reading. This unit proved successful, not only ensuring the correct alum dose to maintain treated water quality, but it also optimised the alum and the lime dosages. The typical lime dose rate under good raw water quality reduced from 12 mg/l to 4 mg/l.

With the improvement in pre lime dosing, the pH control loop required retuning including fitting VSD's to the dosing pumps on the lime system. This meant that as the alum dosage altered, the pre lime dosage adjusted as well to maintain consistent conditions for coagulation. Even with this system operating, the final water quality was still not up to Gippsland Water's expectations of <0.1 NTU, 0 TCU and <0.05 residual alum in the filtered water.

<u>**Figure 1:**</u> ***View of Streaming Current Detector and Pre-Lime pH Meter installation***



3.4 Polymer Dosing

After completing modifications to the coagulation system, the flocculant characteristics of the water was then reviewed. After a long week of jar tests testing various chemicals, it was determined that an additional coagulation polymer and better application of the flocculant was required.

After jar test trials using numerous different polymers, two polymers, one cationic (1190) colour stripping polymer and LT 24, a Flocculant polymer were preferred. Initial tests involved dosing the 1190 in separate locations, however the best results were achieved by mixing it with the alum, at the dosing point.

The next challenge was to change the LT 24 poly dosing points to improve control and application. From past experience, solenoids were not the answer as they continually block up. A modified design involving ball floats, a needle valve and a flow tap was installed. This enables flow versus time tests to be performed, to equalise the dose flow into each cell. It also enables the plant, while doing a back wash, to lift the ball float and cut off the poly flow to the cell being back washed, thus ensuring correct poly dosing continued to the other cell. This system works extremely well, never blocks from the sticky polymers, and is totally independent from any electrical signal.

The water quality now exceeded expectations with the turbidities for floated water reducing to between 0.6 and 1.0 NTU, filtered water to 0.03 NTU and all the colour was removed.

Figure 2: ***View of Flocculant Dosing Point and Isolating Ball Float***

3.5 Pre-Lime Dosing

When the plant inflow reduced 50% during a back wash, the pre-lime dosing pumps could not push the lime solution into the increased pressure in the incoming raw water main.

Two lime solution water carrier pumps were fitted to the lime dosing lines, to increase the pressure of the dosing system. This improvement worked well for a while, but it did not take long for these pumps and the dosing lines to block. A high pressure water line was then fitted to the dosing lines, with a solenoid valve set on a timer, to routinely flush the pumps and lines at set intervals. In addition pipework was set up to allow the provision for a 1% hydrochloric acid wash (if required) to clean the lime dosing lines and pumps. This later addition is not needed as the water flushing keeps the system clean, without any additional maintenance.

To further reduce blockages and dosing pump operation problems, the lime solution strength was reduced. The original lime solution was around 5% which is too concentrated for the lime system to work with out regular maintenance. The lime dosing pumps were also operating at very low speeds and this caused dosing line and pump blockages.

The lime solution mixing tank has a capacity of 200 litres and in order to change the dosing solution to meet changes in raw water quality, at least 20 minutes would be required to allow change of solution strength. This caused problems with adequate response times in line with alum dose.The solution strength was reduced to 1% and working with the dosing pumps speeds, an algorithm was developed and programmed to maintain a 1% lime solution until the raw water turbidity reached 50 NTU. At this point the solution changed to 2% to assist with the increased alum dose utilizing the VSD's on the lime pumps.

Larger, higher pressure carrier pumps were fitted so that only one pump would need to run to overcome the highest pressures in the raw water main. When the incoming flow drops below 8 ML per day both carrier pumps can run if required, to overcome the higher static head pressure in the main. This system has been in operation for 10 months with minimal maintenance being required and with correct control of coagulation pH occurring.

Figure 4: ***View of Lime Dosing System (Mixing tanks in the back, dosing pumps in the foreground and carrier pumps to the left)***

3.6 Cell Floats

The solids raised by the DAF process were removed from the cells every two hours. This process takes 4 minutes with the floated solids discharged to the waste water lagoon. During high turbidity events additional solids are floated and the sludge blanket can become very thick. The PLC program was altered so that when the raw water turbidity reaches 50 NTU, the solids removal from the cells will be undertaken every 1 hour, again for 4 minutes. This enables the sludge blanket in each cell to be kept stable.

3.7 Service Water

The original service water pump system was located in the chlorine room, approx 200m away. The service was capable of producing 600 kPa and the service water was used in the chemical dosing system. After modifying the lime systems, at least 700 kPa was necessary to service all requirements.

The recycle water from the DAF system was capable of 750 kPa, therefore it was decided to try it as the supply of the service water. A problem with this sytem was that when the plant was shut down, the air from the DAF system would enter the service water pipes and pressures would build up in the pipes. It then blew an elbow off a service water pipe due to built up pressure. It also effected the DAF performance, particularly during dirty water events, because water flow was being redirected to the service line.

Following further review, it was decided to fit new service water pumps that were capable of 1200 kPa, with an adjustable relief valve to control the maximum pressure. This pressure exceeded the volume required to ensure the chemical dose systems worked correctly. This modification also provided additional capacity should plant duplication be required to meet future water demand.

The service water offtake was connected to the out going manifold from the plenum on each filter cell so that treated water to dose chemicals would be available under all operating scenarios. This gives the option of two supplies (one on each filter cell), so that if it was ever decided to only run one cell, a valve can be closed isolating the cell that is off line. It also provides the benefit of clean water. These pumps were set up on a duty select system, so that if one of the pumps failed the other pump would automatically start up.

3.8 Plant Operating Fail-Safe Systems

Following a review of the treatment plant fail-safe alarms, the following options were implemented to avoid dirty water entering or leaving the treatment plant.

- SAMPLE FLOW METER - A flow meter was installed on the pumped sample line that supplied water to the incoming pH meter and the streaming current detector so that if the pump stopped the PLC would automatically shut the treatment plant off and send an alarm to the operator.
- pH ALARM – Alarm parameters were set for the incoming pH, with low and high set points of 5.6 and 6.6 respectively. If the raw water pH moves outside these settings, the treatment plant would automatically shut down and send an alarm to the operator.
- RAW WATER QUALITY – Alarm parameters were set for treated water leaving the treatment plant exceeding 0.5 NTU, the treatment plant automatically shuts down and sends an alarm to the operator.
- RAW WATER FLOW CONTROL – To assist in controlling high raw water turbidity events, the ability to reduce raw water inflow based on turbidity measurements was developed and installed. This can also be used to shut the treatment plant down, if required for extreme events.
- STORAGE START/STOP LEVELS - Level sensors were fitted the main storage reservoir and the chlorine contact tank to stop and start the treatment plant on water levels. High and low level float alarms were also fitted as a safety back up.

3.9 Noise Room

The main plant room area housing the compressors and air scour blowers was an open room with noise levels exceeding specified limits. A sound proof room was constructed and the noisy compressors, blowers and DAF recycle pumps were relocated into this room. This relocation cut the noise levels so much that the additional works of covering the treated water outlet chamber (a noise not heard before) needed to be undertaken. The treatment plant is now very quiet, and a comfortable place to work.

3.10 Chlorine Contact Tank

A new roof was built over the old clarifier and it was converted to a chlorine contact tank with a full capacity of 4.2 ML. The roof was constructed from painted aluminium to blend in with the surrounding environment, and to provide a minimum life of 40 years.

The chlorine contact tank enables the required dose of chlorine for primary kill, and allows a consistent residual of around 0.3 mg/L to be maintained instead of losing most of the residual through the day. After leaving the tank the water is further chlorinated to maintain a residual up to 0.6mg/L before entering the reticulation pipe works.

This contact tank has an added benefit in that chlorinated water can still be supplied to customers even in the event of a power failure.

The main storage reservoir has a capacity of 50 megalitres. This is to be lined and covered. This will protect the reservoir from the spread of pathogens from birds and animals.

3.11 Back Wash Pump Noise Proof Room

A sound proof room was fitted over the backwash pumps . This now means backwashing can be undertaken at any time day or night, without disturbing the neighbours that live adjacent to the plant.

4.0 CONCLUSION

After resolution of the above issues, the Warragul Water Treatment Plant is now a reliable and consistently performing treatment plant. It consistently produces high quality water with turbidity's of 0.03 to 0.04 NTU, zero TCU and alum residuals of 0.02 to 0.03mg/L, despite significant variations in raw water quality.

The additional alarming and safety features that have been fitted protect the plant from failure, avoid dirty water from being released into the plant, shut it down if there is an operational fault, and prevent poorly treated water from entering the reticulation system.

The lime system is now low maintenance and very reliable. A lot of work and thought has gone into this system and it now controls the post and pre post dosing with out fear of pump failure or blockages. The VSD's that were fitted to the lime dosing pumps, allow the lime dose rates to change very quickly and track the alum dose rate to maintain the required pH for coagulation.

OH&S audits have been very positive with extra safety features fitted to protect the operator and visitors to the site.

5.0 ACKNOWLEGEMENT

The author wishes to thank Ian Soutar, for his experience, knowledge and support during the alterations and works that took place in the commissioning of the new Warragul Water Treatment Plant.